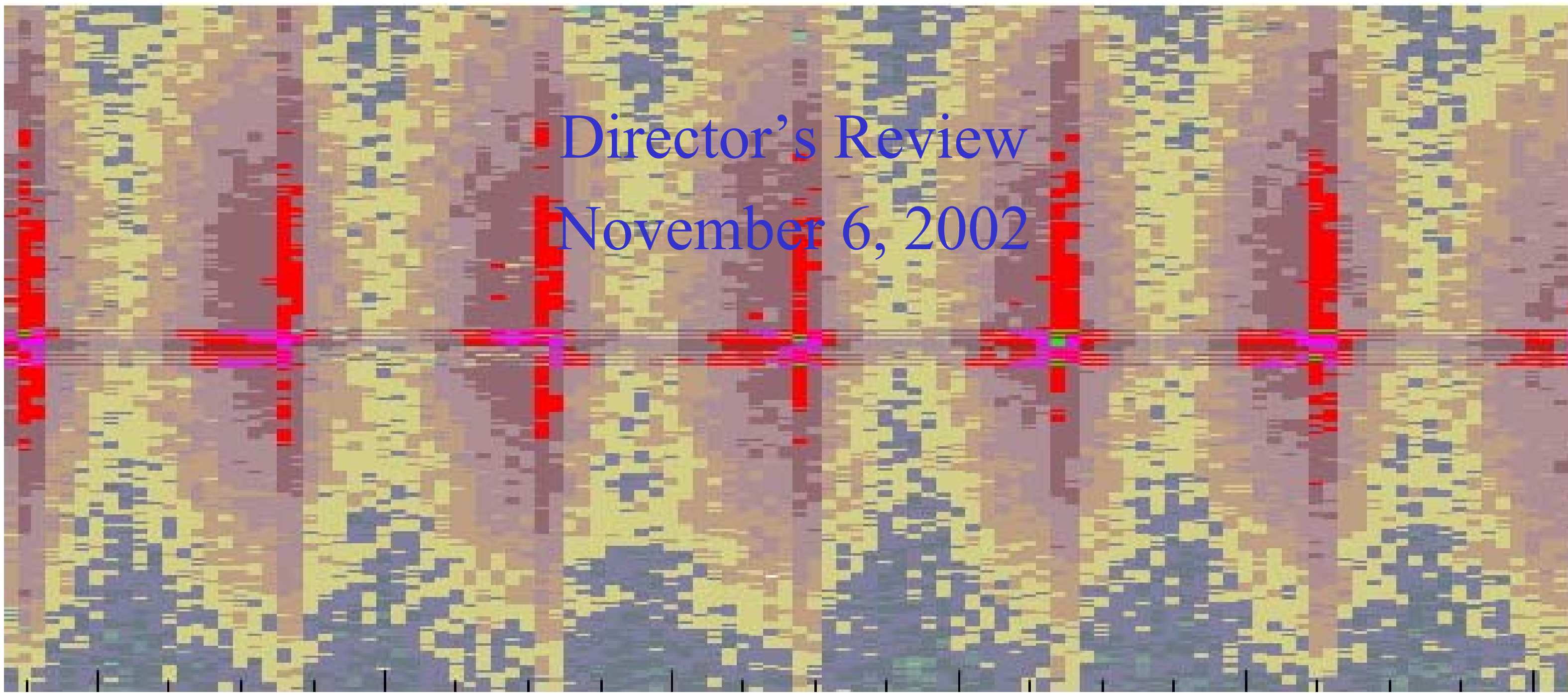
ATLAS



Director's Review

November 6, 2002

M. Gilchriese

ATLAS Group

M. Barnett, V. Chang, A. Ciocio, A. Clark, **D. Costanzo**, *S. Dardin*, **M. Dobbs**, K. Einsweiler, **V. Fadeyev**, *J. Freeman*, M. Garcia-Sciveres, M. Gilchriese, F. Goozen, M. Gregor, C. Haber, I. Hinchliffe, K. Huang, S. Loken, J. Lys, S. McIntyre, J. Richardson, **A. Saavedra**, M. Shapiro, H. Spieler, J. Snow, G. Stavropoulos, G. Trilling, *J. Virzi*, *T. Weber*, *R. Witharm*

Physics Division and UC Berkeley

E. Anderssen, L. Blanquart, A. Das, P. Denes, N. Hartman, *J. Hellmers*, B. Holmes, *T. Johnson*, J. Joseph, E. Mandelli, G. Meddeler, *R. Powers*, A. Smith, T. Stillwater, *C. Tran*, C. Vu, *J. Wirth*, *G. Zizka*

Engineering Division

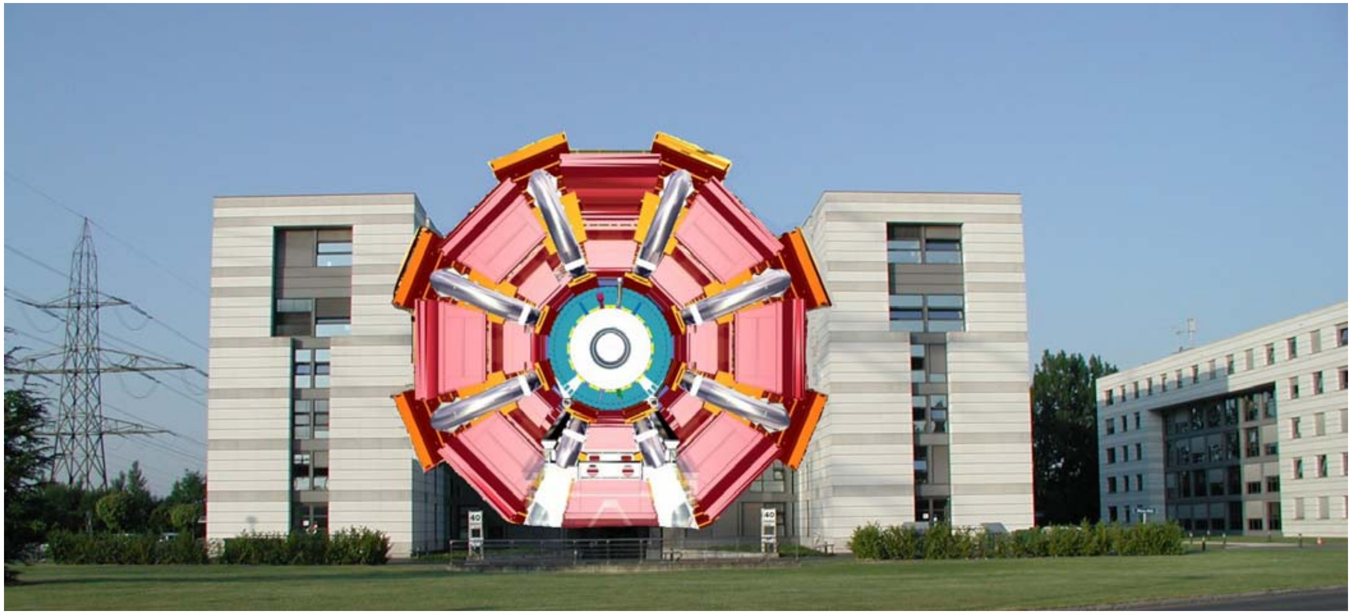
P. Calafiura, W. Lavrijsen, C. Leggett, M. Marino, D. Quarrie, C. Tull

NERSC

Physicist **Postdoc** *Grad Student* Undergraduate Engineer *Technician*

ATLAS Overview

- ATLAS is fully into production and many final components have been delivered to CERN. Substantial progress in last year.
- Installation underground will begin next year and global commissioning is planned for 2006.
- Although many schedules are tight, it is feasible for ATLAS to be ready for first LHC beam in 2007.



M. Gilchriese

Current LBNL Roles in ATLAS

- Software, computing and physics simulation
  - Lead role in the development of the Athena framework code(the "operating system" for ATLAS software)
  - Lead role in development and maintenance of physics simulation tools
- Silicon strip detector
  - Test system for integrated circuits completed and in operation
  - Module production starting
- Pixel detector
  - Lead roles in electronics, mechanics and coordination of modules
  - Production started on mechanical supports and silicon detectors
  - Electronics and module prototypes under test, planning for module production to begin summer 2003.

Highlights Since Last Year

- Use of the Athena software framework in Data Challenge 1(Phase I) across 18 countries using up to 3200 processors, which produced 30 Tbytes of data.
- Start of production of silicon strip modules.
- Success of first 0.25μ full-prototype pixel front-end chip, validated by extensive irradiations and test beam measurements. First demonstration that pixel assemblies can meet LHC requirements.

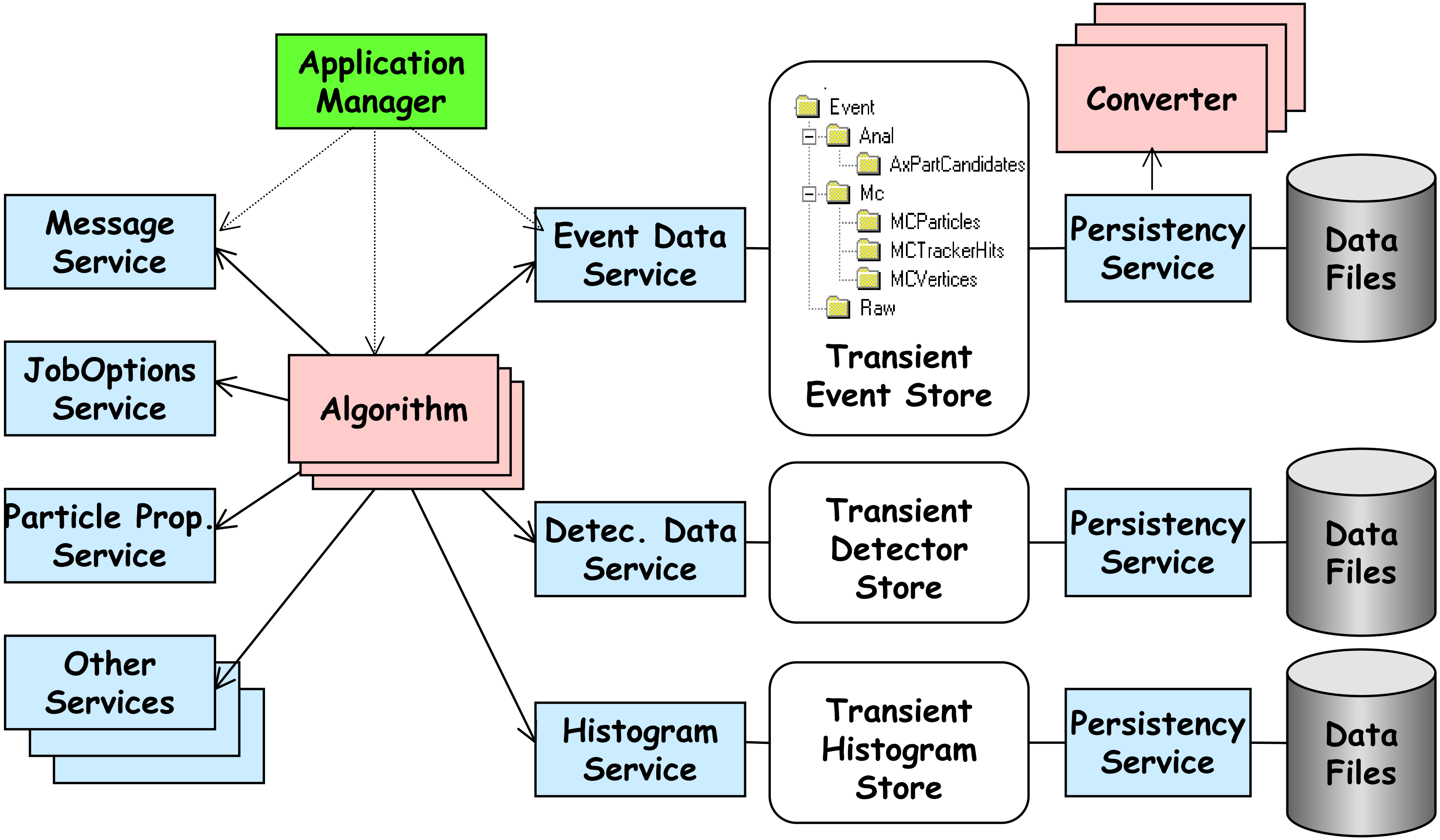
ATLAS Computing Overview

- Data challenges completed or underway
  - DC0 – a “continuity” test of system. Completed
  - DC1(Phase I) – simulated events to study high-level triggers(for preparation of Technical Design Report) and to advance system. Completed.
    - Events simulated ~10^7
    - 18 countries, 39 institutions involved, completed in August
    - LBNL provided cycles on PDSF via Grid, support person partially funded by Division.
  - DC1(Phase II) – underway. 70 Tb goal. More countries, more Grid
- Future data challenges
  - DC2: Q3/2003 – Q2/2004. Move towards GEANT4, pile-up, more Grid…10^7 events
  - DC3: Q3/2004 – Q2/2005. 5 x DC2
  - DC4: Q3/2005 – Q2/2006. 2 x DC3
- Recent formal agreement on Grid model for much of ATLAS computing ie. countries agree to provide resources to all of collaboration based on fraction of scientific authors(U.S. is the largest).

LBNL and ATLAS Computing

- D. Quarrie is the ATLAS Chief Software Architect.
- LBNL personnel are largely responsible for the ATLAS framework code – Athena
  - Athena based on GAUDI developed for LHCb. Some continued joint development with LHCb.
  - Structure in which the user code operates – see diagram next page
  - Provides access to data, histogramming, skeleton for user code…..all of the core functions
  - Everyone must use the framework, and it is now fully accepted within ATLAS(a non-trivial accomplishment)
  - Our work is covered under a signed software agreement.
  - P. Calafiura heads the Athena framework effort.

Athena/GAUDI Architecture



M. Gilchriese

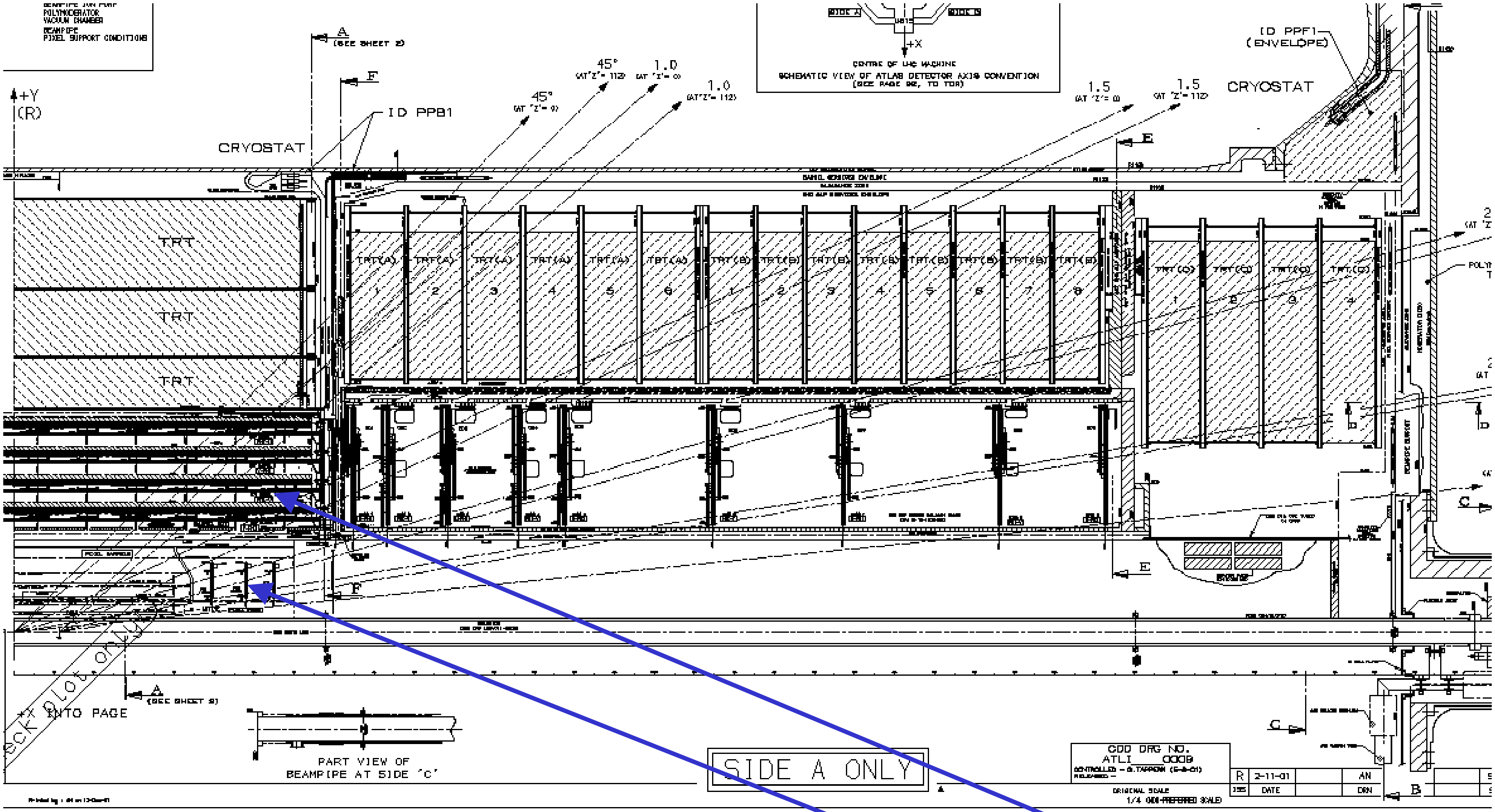
Recent Athena Developments

- Migrated to new operating system and tutorials(Marino at CERN).
- User interface(Lavrijsen). Athena startup kit.
- Conditions data store(Leggett). Time dependent data(eg. calibration) handling.
- GEANT4 integration(Leggett). Stand-alone simulation framework now gone.
- Athena Data Dictionary and Description Language(ADL)(Tull). How data are "written out" of Athena. Shields users from persistency tools.
- Pile-up service(Calafiura). Handle pile-up during (simulated) reconstruction. Detectors have different requirements(integration times).
- Event data model(Quarrie coordinating).

Physics and Detector Simulation

- I. Hinchliffe is the U.S. ATLAS physics coordinator and has a major ATLAS-wide role in the development and verification of simulation software. G. Stavropoulos(UC Berkeley) supports development and maintenance of simulation tools.
- LHC upgrade studies. Energy and luminosity upgrades, mostly luminosity upgrades(10^{35}). Final report generated. Physics reach improvement interesting, experimental challenges (particularly for tracking) daunting.
- Studies of signatures for extra dimensions and SUSY studies. First major full simulation of SUSY events in ATLAS is now just starting as part of DC1(PhaseII), led by Ian.
- GEANT4 simulation of pixel detector advancing well(D. Costanzo)
- M. Dobbs is co-convenor of Standard Model Working Group.

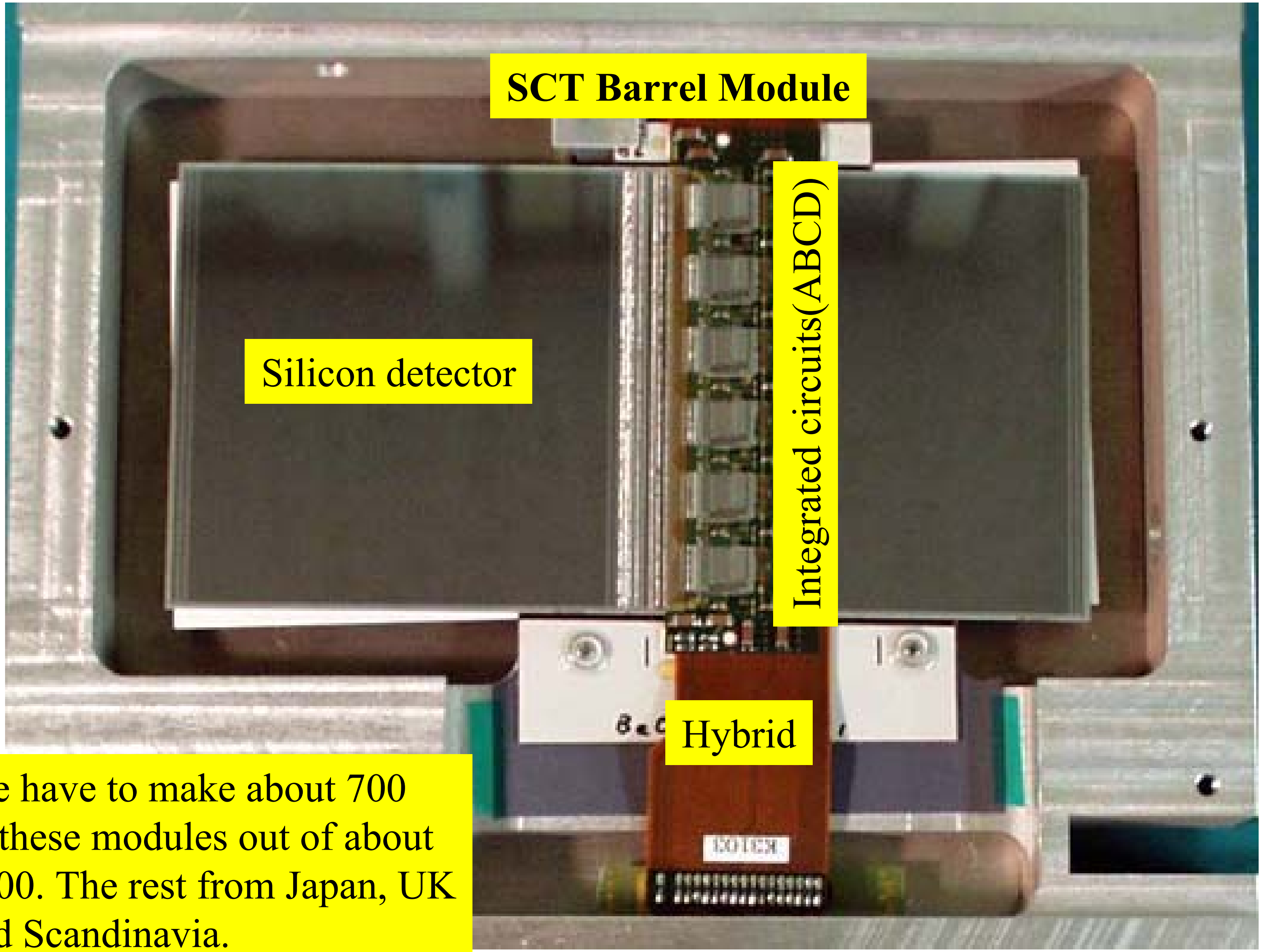
ATLAS Inner Detector



LBNL Technical Roles in Pixels and SCT

M. Gilchriese

Silicon Strip Detector(SCT)



We have to make about 700 of these modules out of about 2000. The rest from Japan, UK and Scandinavia.

SCT Integrated Circuits

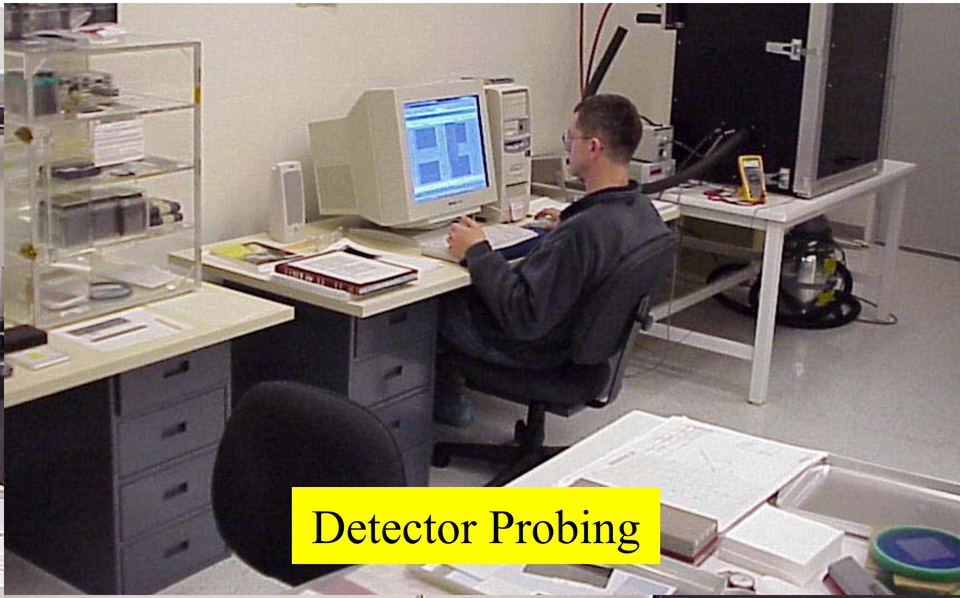
- LBNL originated, designed and built custom, high-speed test systems for the SCT integrated circuits (ABCDs). This has made it possible to keep up with delivery of wafers.
- Test systems are at UCSC(2 stations), RAL(1 station) and CERN(1 station).
- About 2/3 of the total ICs needed have been tested and testing will end in early 2003.
- LBNL personnel(Ciocio, Fadeyev, Vu) remain in maintenance mode and to help understand correlations between wafer-probe data and data from hybrids.

SCT Hybrid&Module Production

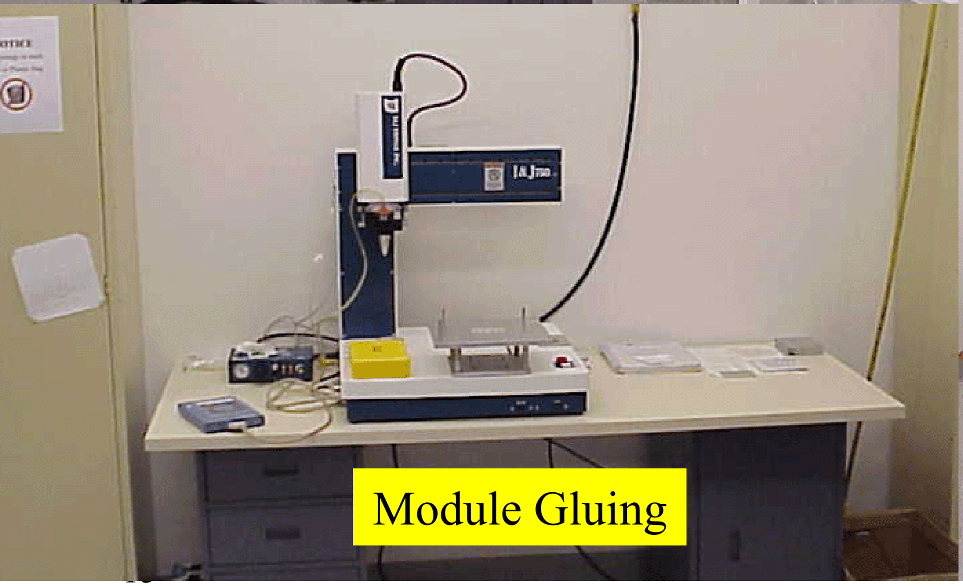
- Production facilities in place in clean room in Bldg. 50 for
  - Chip placement on hybrids and wire bonding
  - Detector probing
  - Mechanical module assembly
  - Mechanical metrology(few micron accuracy)
- Facilities for electrical testing of hybrids and modules in place in Bldg. 50 to perform
  - Hybrid testing at points in the wire bonding sequence
  - Tests after complete assembly of a module
  - Burn-in under temperature and humidity control

SCT Hybrid/Module Production

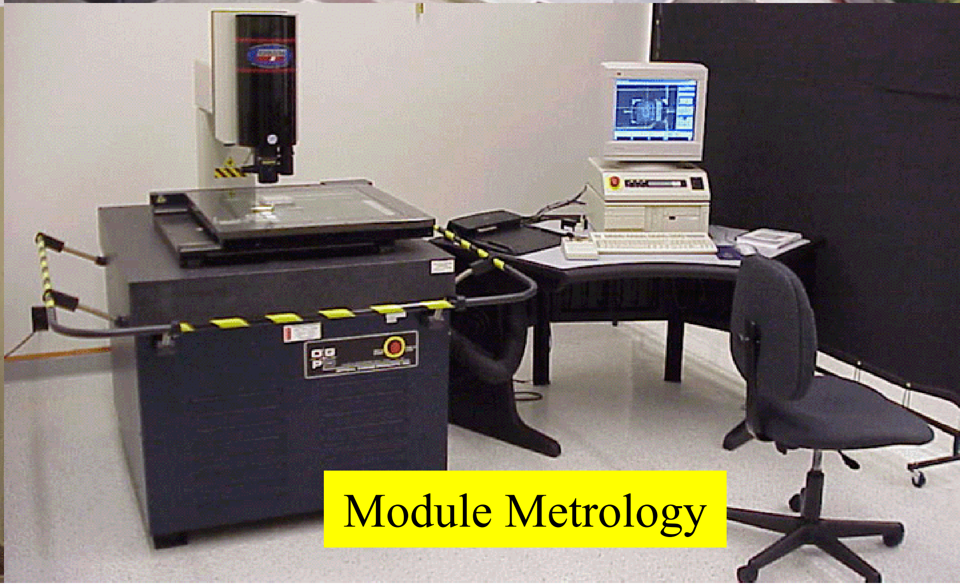
Mechanical Assembly



Detector Probing

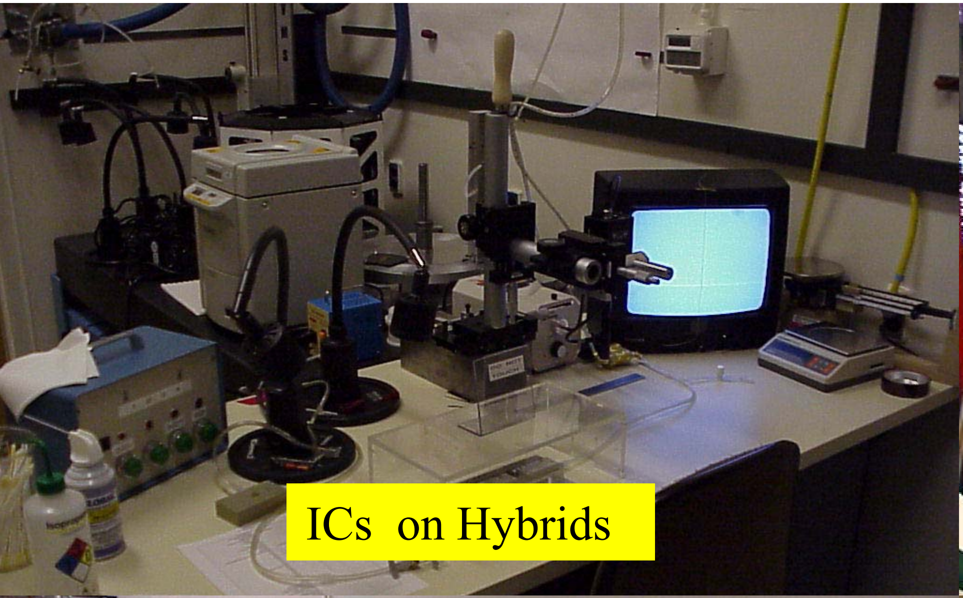


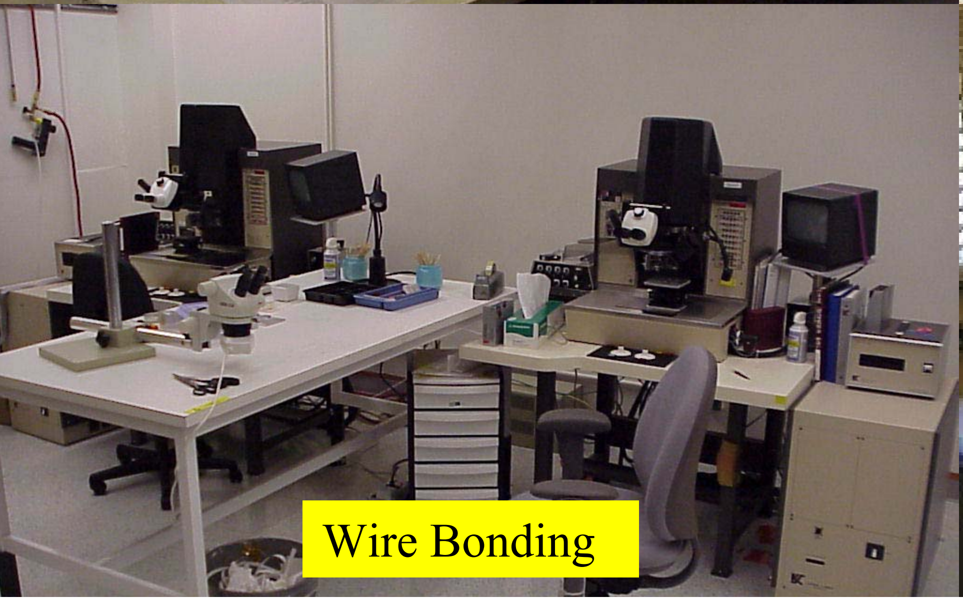
Module Gluing

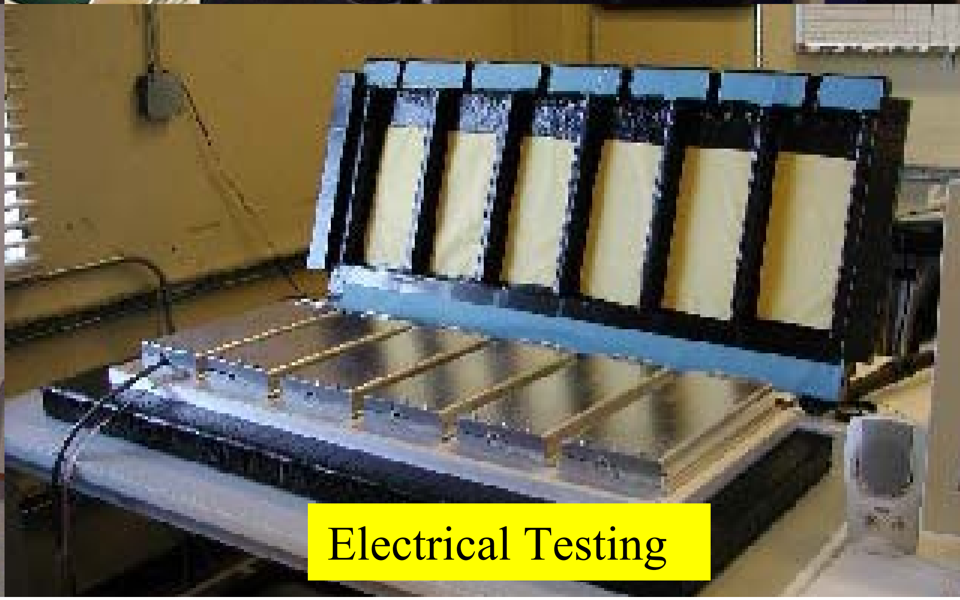


Module Metrology

SCT Hybrid/Module Production







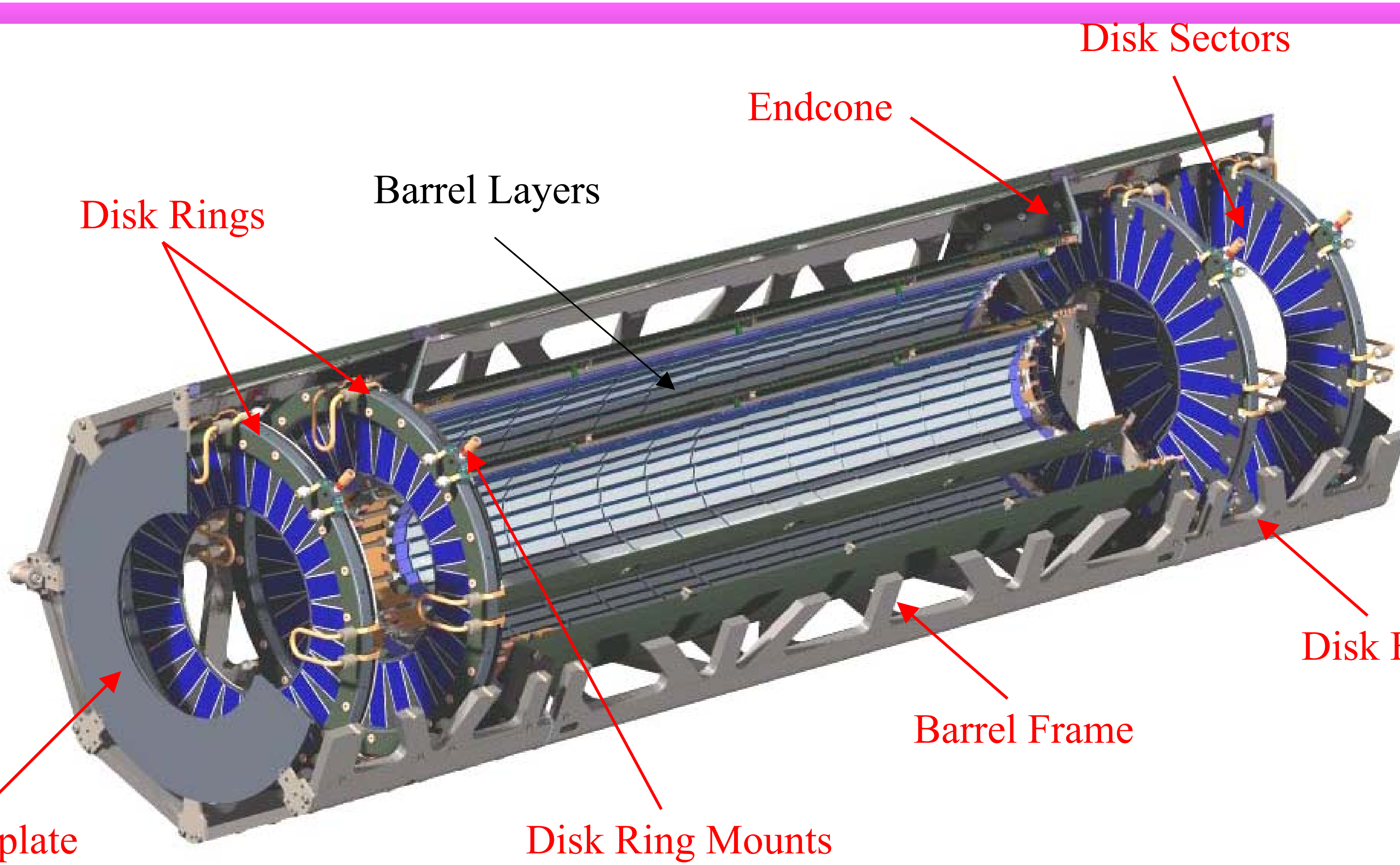
SCT Module Production

- We have made about 10 electrically functional modules and have made about 25 dummy modules of various types as part of the qualification of our procedures.
- We have assembled and tested about 25 electrically functional hybrids.
- Our ramp up to a full production rate(3 modules per day) has been slower than desired.
  - Technical problems with baseboards(UK) and hybrids(Japan) have delayed delivery of these items to us.
  - We have requested some modifications to the assembly process and it has been slow to get general agreement to do this.
  - Can meet current mechanical specifications on internal alignment about 90% of time. We are continuing work to control this better and are encouraging a new look at the most demanding specification.
- We are collaborating closely with Santa Cruz on hybrid assembly and testing and hybrid rework. We expect Santa Cruz to be able to begin hybrid assembly by early next year, using tooling and procedures developed here.

Read-Out System

- The SCT(and pixel) systems are read out using VME boards located about 100m from the experiment, on the other end of long fiber optic cables.
- The design and fabrication of all of the boards necessary to read out the SCT and pixel systems is a US responsibility.
- The design work is done by LBNL engineering funded through the University of Wisconsin. Wisconsin supports the effort by having a postdoc resident at LBNL.
- We have bolstered this effort by student support and some involvement(in the pixel design) by LBNL-supported engineering.
- The final production of the SCT boards is planned for Spring 2003, to be followed afterwards by the pixel boards.

Pixel System



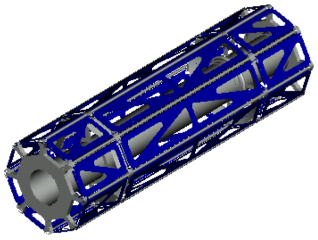
LBNL mechanical responsibilities shown in red

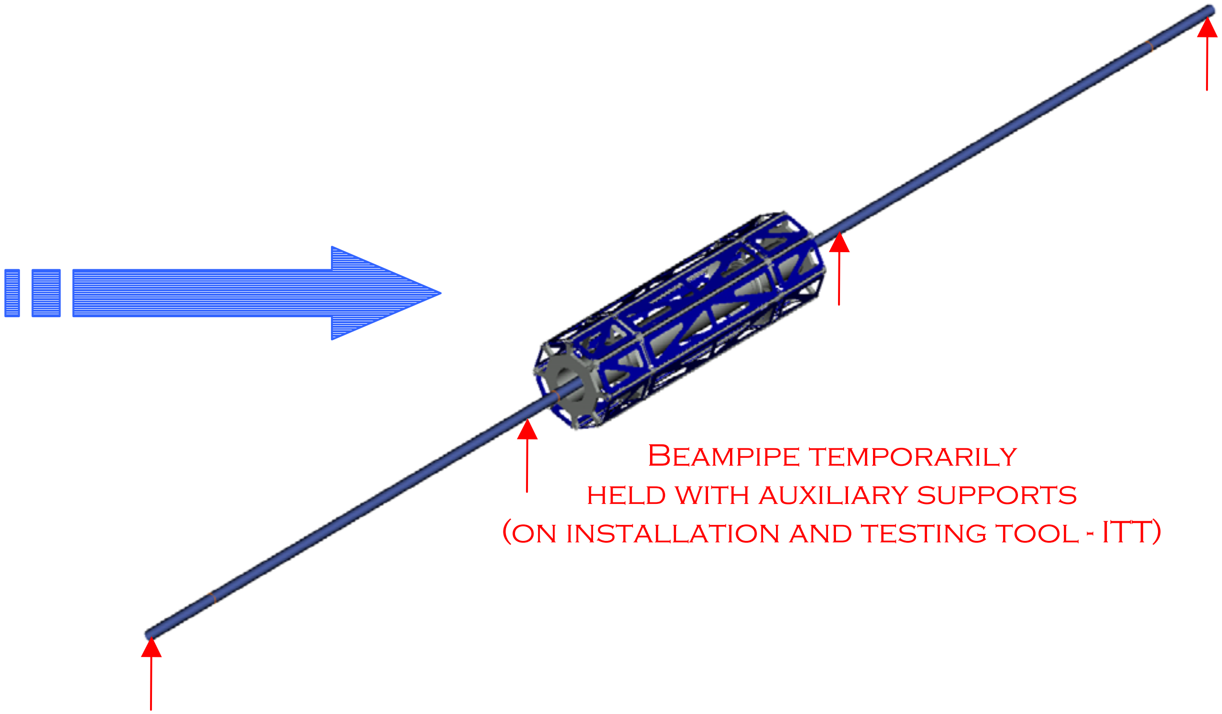
(Services not shown)

Pixel Size is 50x400 microns

Pixel and Beam Pipe Assembly

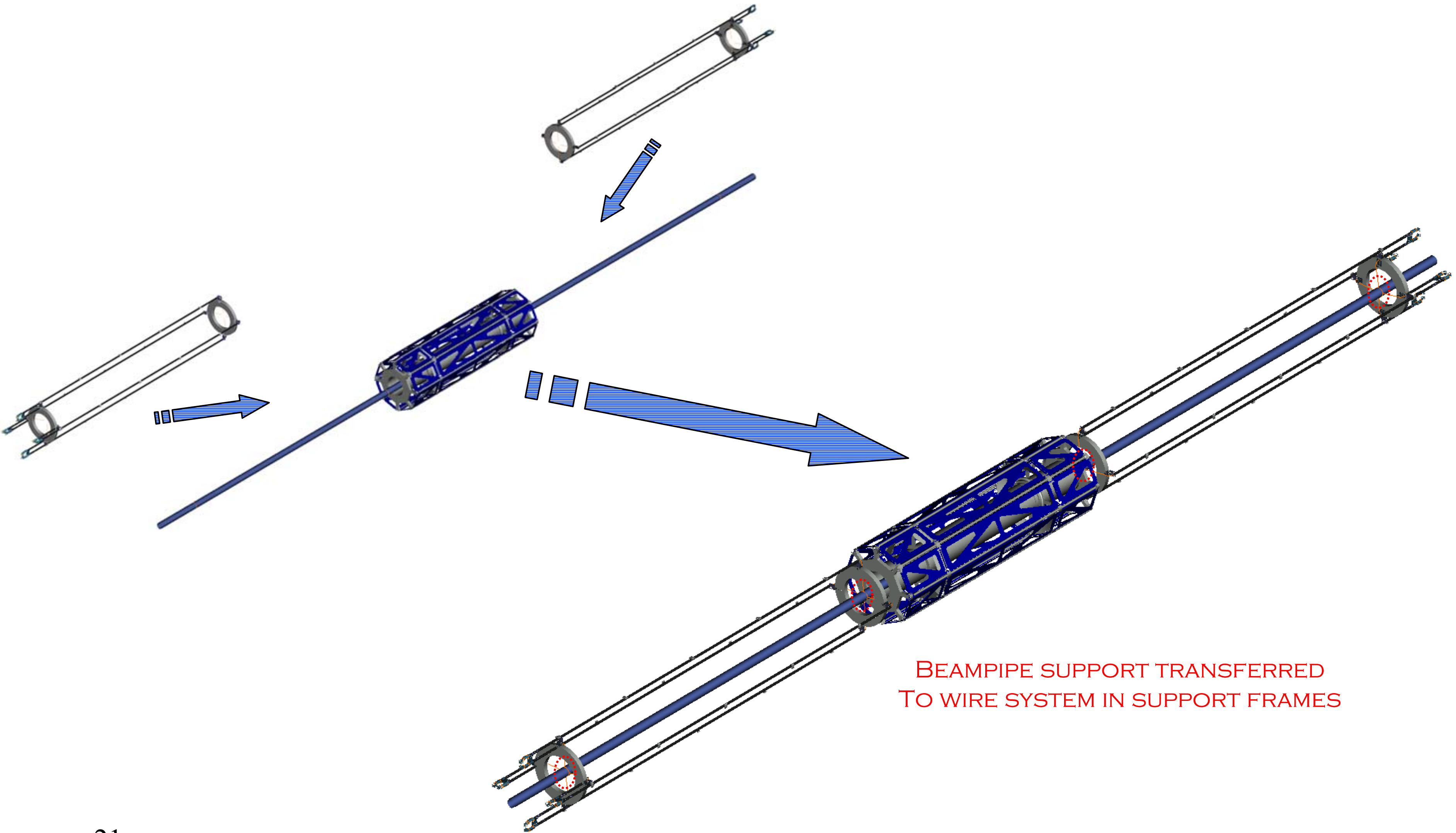
Pixel system and beam pipe will be
Assembled on the surface and lowered
As a package into the collision hall



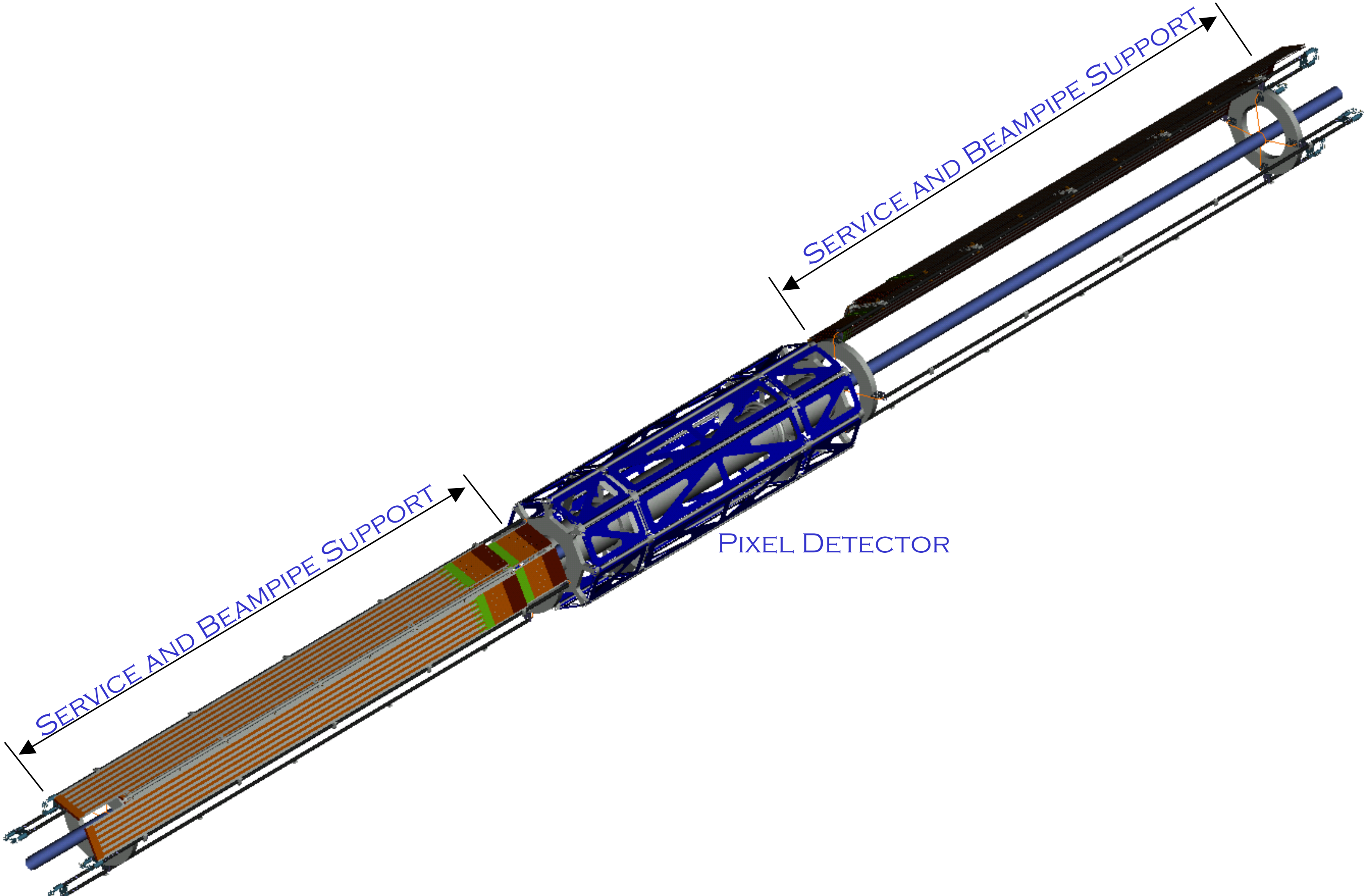


Beampipe temporarily
held with auxiliary supports
(on installation and testing tool - ITT)

Pixel and Beam Pipe Assembly

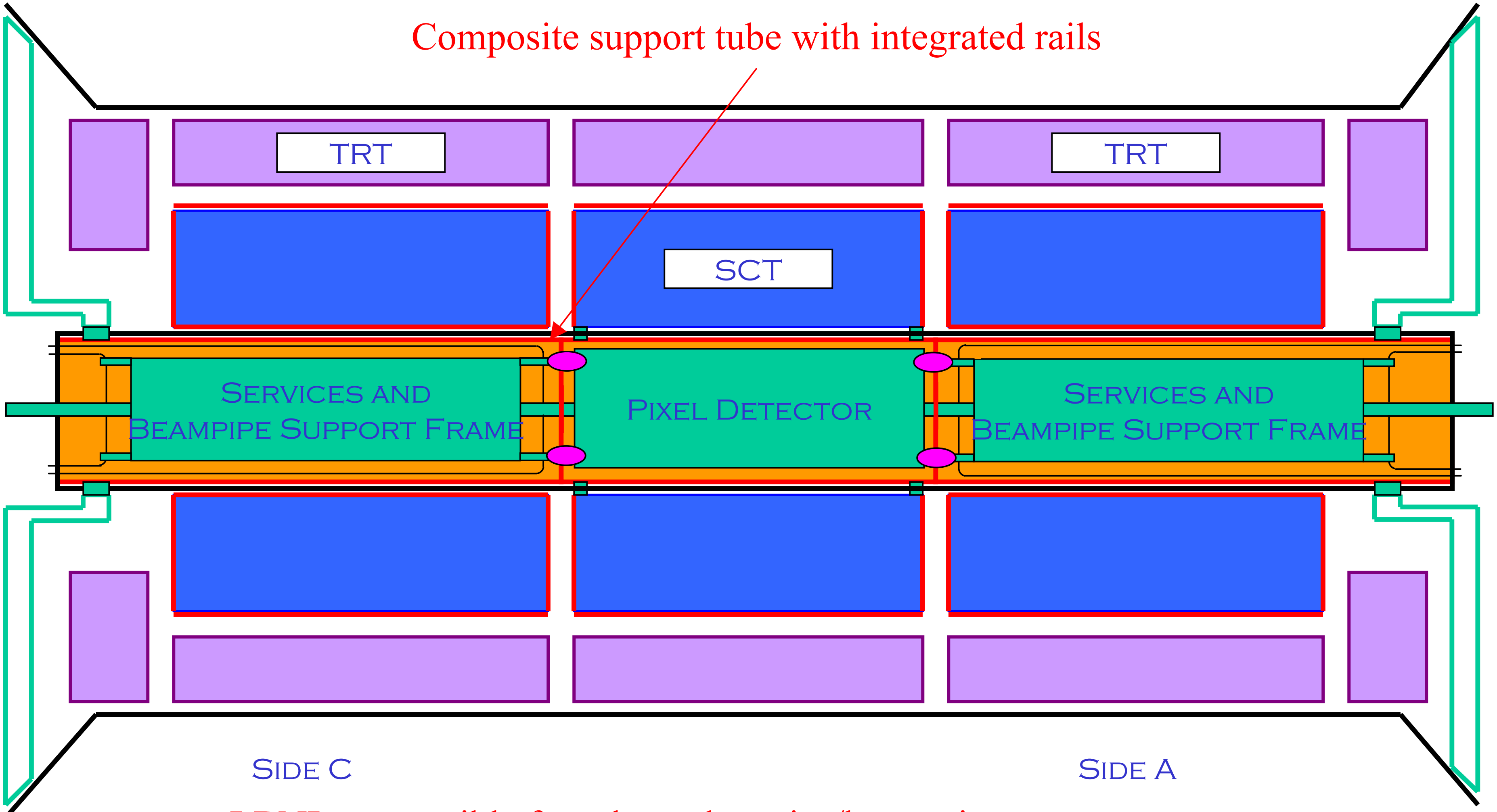


Pixel and Beam Pipe Assembly



Pixels Installed

Composite support tube with integrated rails

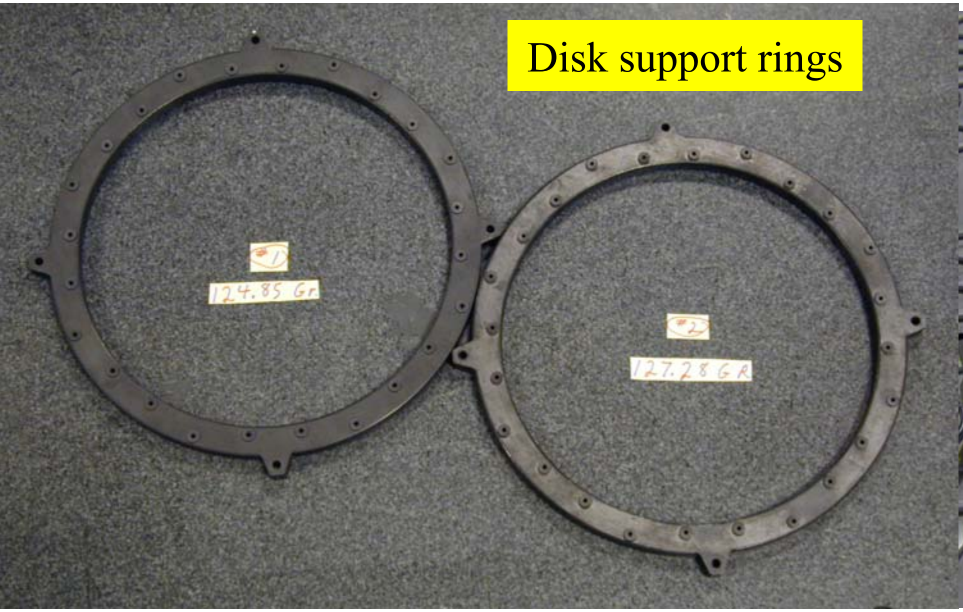


LBNL responsible for tube and service/beam pipe support structures

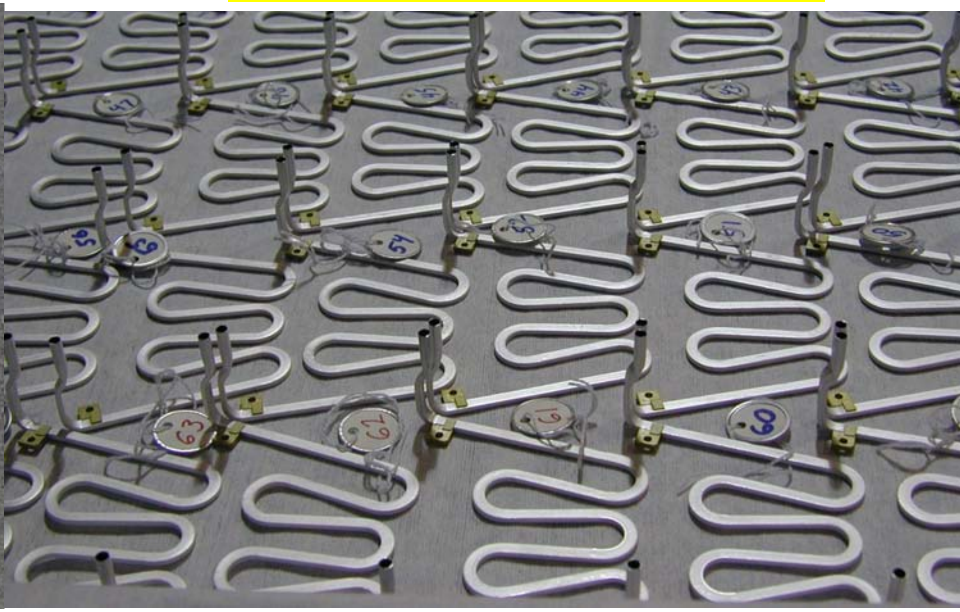
M. Gilchriese

Pixel Mechanics I

- Fabrication of the pixel support structures is proceeding well and will be completed by summer of 2003.
- The support frame and disk support rings are being fabricated at an external vendor and the disk module supports(sectors) made here at LBNL.



Aluminum tubes for disk sectors

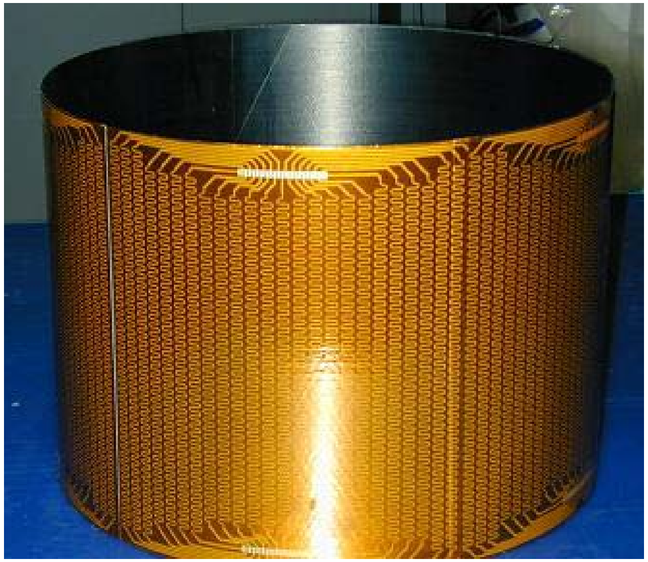


M. Gilchriese

Pixel Mechanics II

- The 7m long support tube(in 3 sections) will be made at LBNL using autoclave and other items purchased by the Engineering Division.
- Prototypes of this tube, heaters and rails have been made and final fabrication will begin the Spring of 2003.

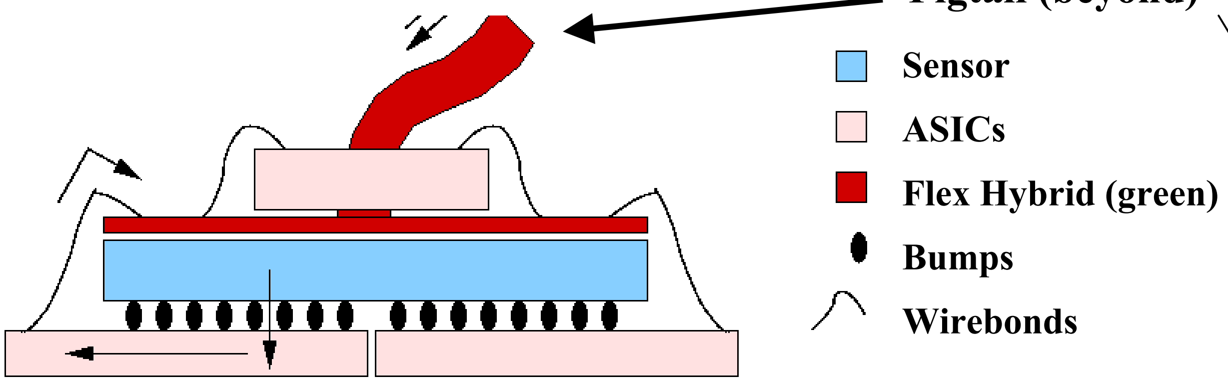
Prototype tube section with heaters.



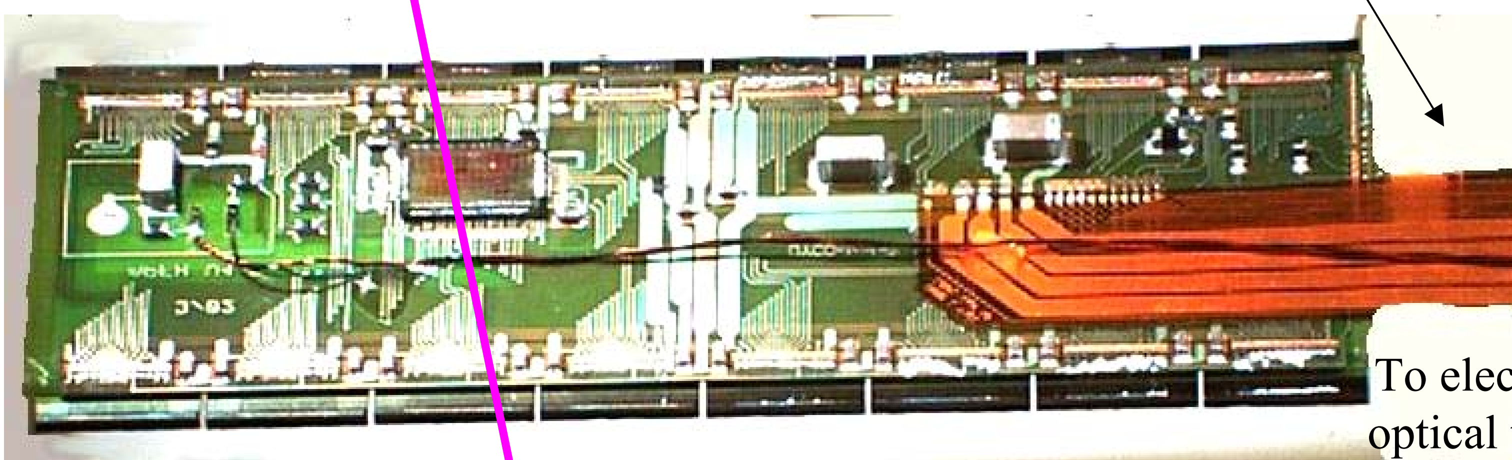
M. Gilchriese

Pixel Hybrids and Modules

- M. Garcia-Sciveres is the overall ATLAS module coordinator,



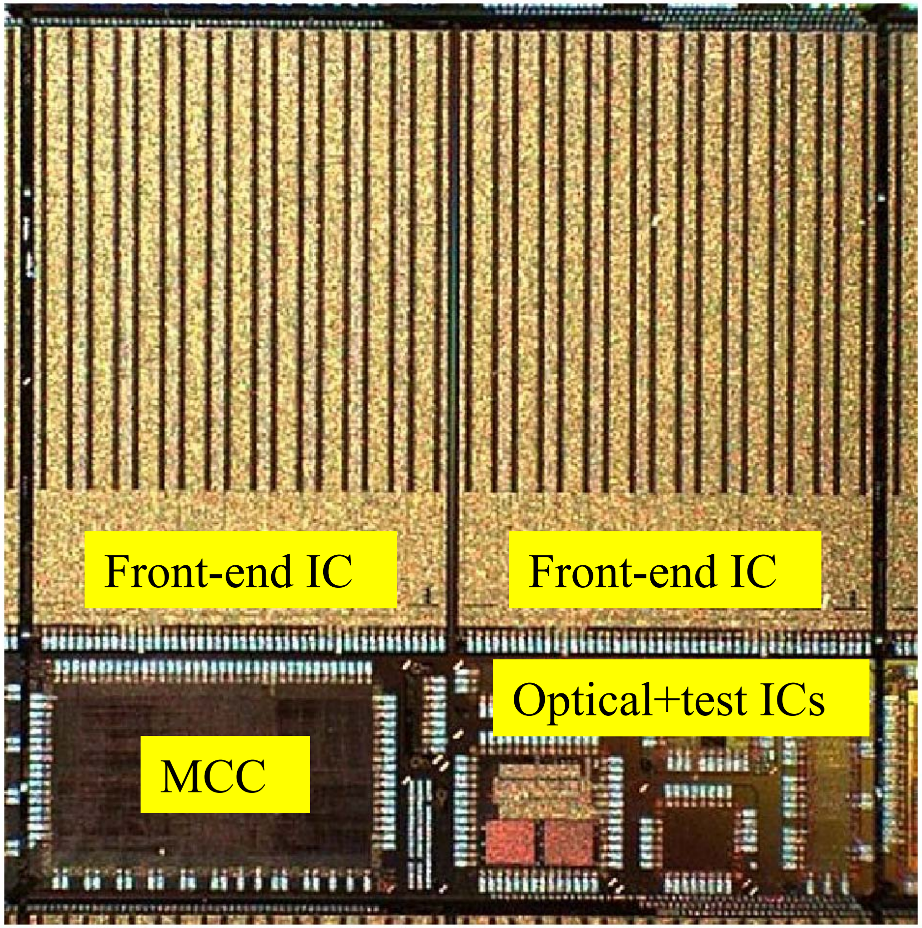
Schematic Cross Section
(through here)



Pixel Electronics

- K. Einsweiler is the overall ATLAS pixel electronics coordinator.
- The strong LBNL IC group allows us to lead the pixel electronics effort(Blanquart, Denes, Mandelli, Meddeler)
- In addition, we are responsible for providing most of the IC and module tests systems for the collaboration, and these have also been designed and implemented by Einsweiler, Saavedra and LBNL engineers(Joseph, Richardson, Vu)

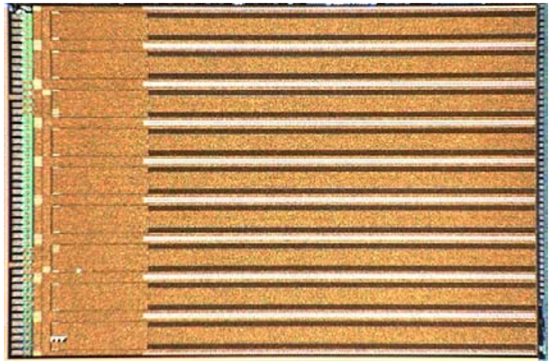
Reticle from 0.25µ IBM



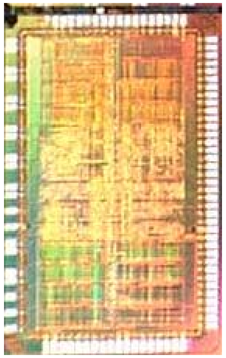
Pixel Integrated Circuits

- First delivery of wafers from IBM with full-chip set in January this year. Wafers from multiple lots were delivered with varying yield(there are some processing problems at IBM seen also by other experiments).
- Chips work rather well. Lab and beam tests complete, fabrication of about 100 prototype modules in progress.

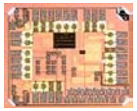
Front End Chip
2880 channels



Module Control Chip
Manages data & control
between module's 16 chips



Optical interface chips



Doric
(from PIN diode to decoded LVDS)

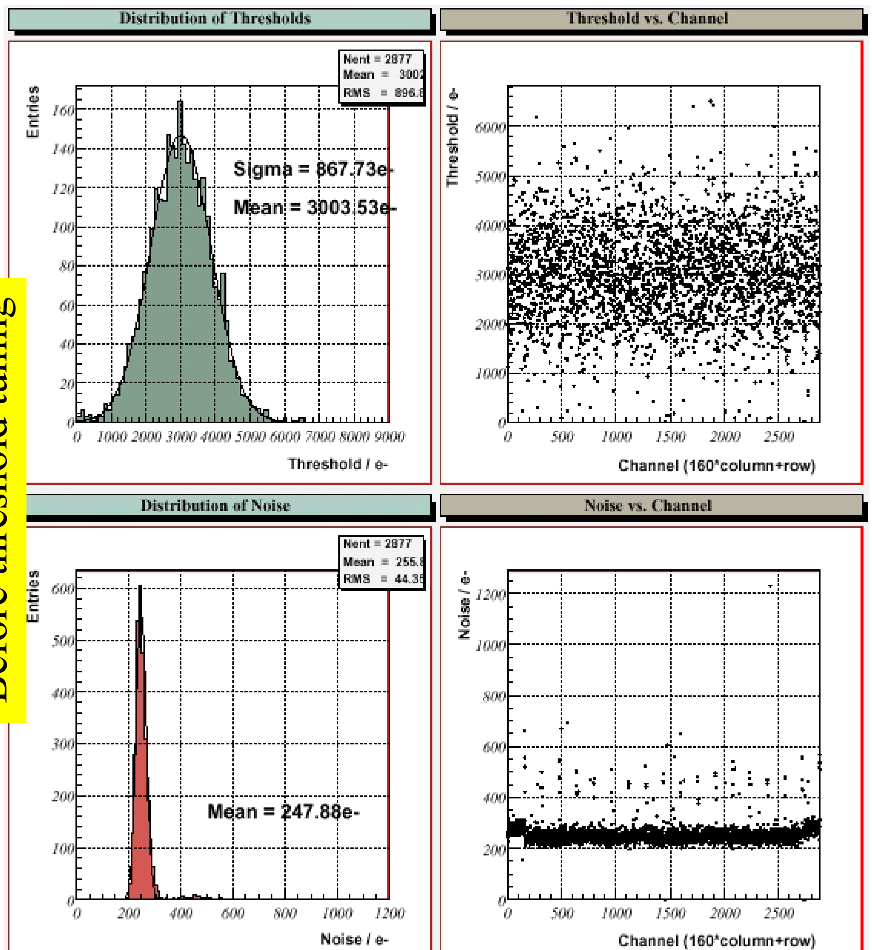
VDC array
(from LVDS to laser diodes)

M. Gilchriese

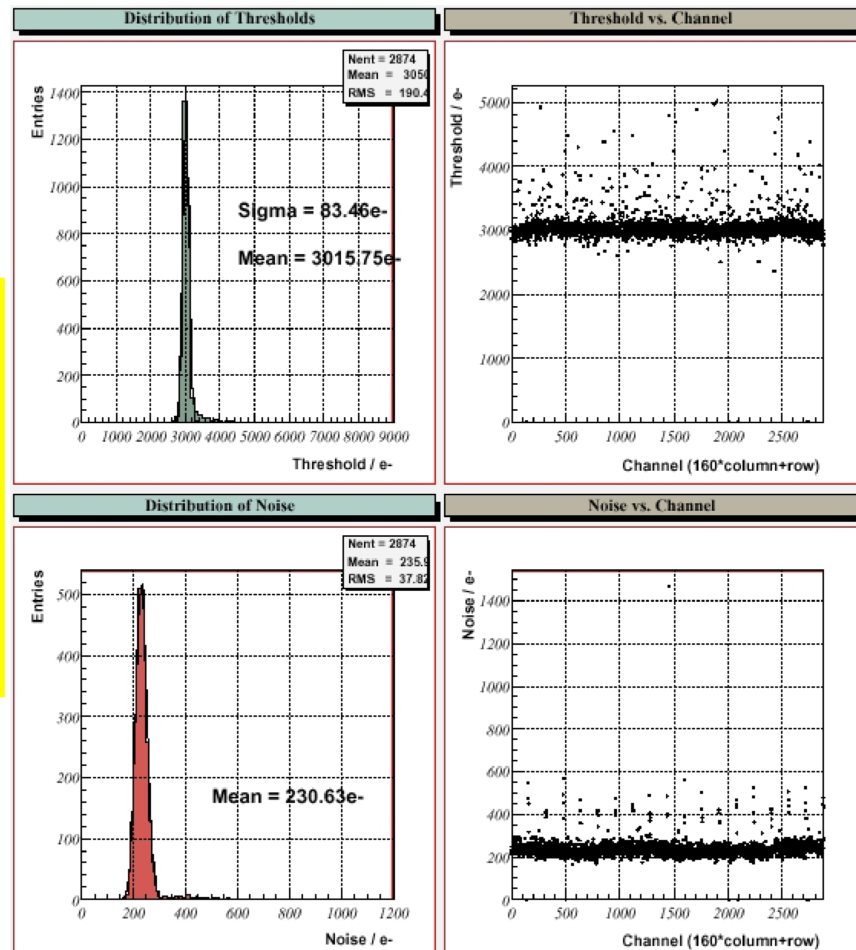
Front-End Performance

- 1st prototype largely meets requirements, including after 50 MRad+ irradiation.
- Improvements to threshold tuning and resistance to Single-Event-Upset will be made in next version under design/layout now, as well as other improvements.

Before threshold tuning



After threshold tuning



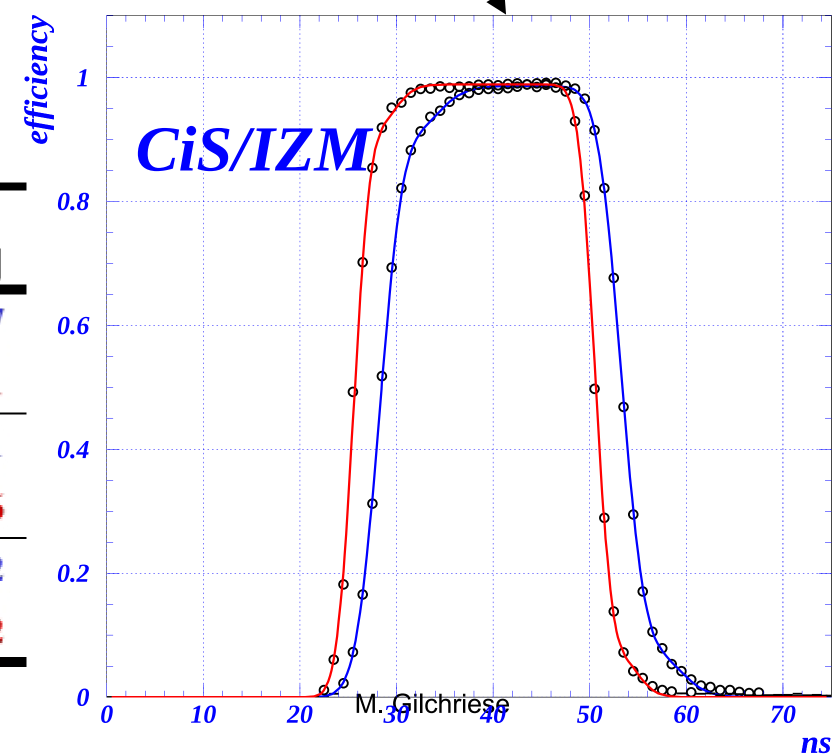
Test Beam Efficiencies

Chip	ε [%]
0	99.15
1	99.22
2	99.64
3	99.61
4	99.70
5	99.68
6	99.64
7	99.65
8	99.72
9	99.72
10	99.71
11	99.65
12	99.67
13	99.62
14	99.60
15	98.95

Unirradiated module
Noise occupancy is
< 6×10^{-9} per pixel

Single-chip assemblies irradiated to about lifetime dose with different sensors and bump bonds. Different chip configurations.

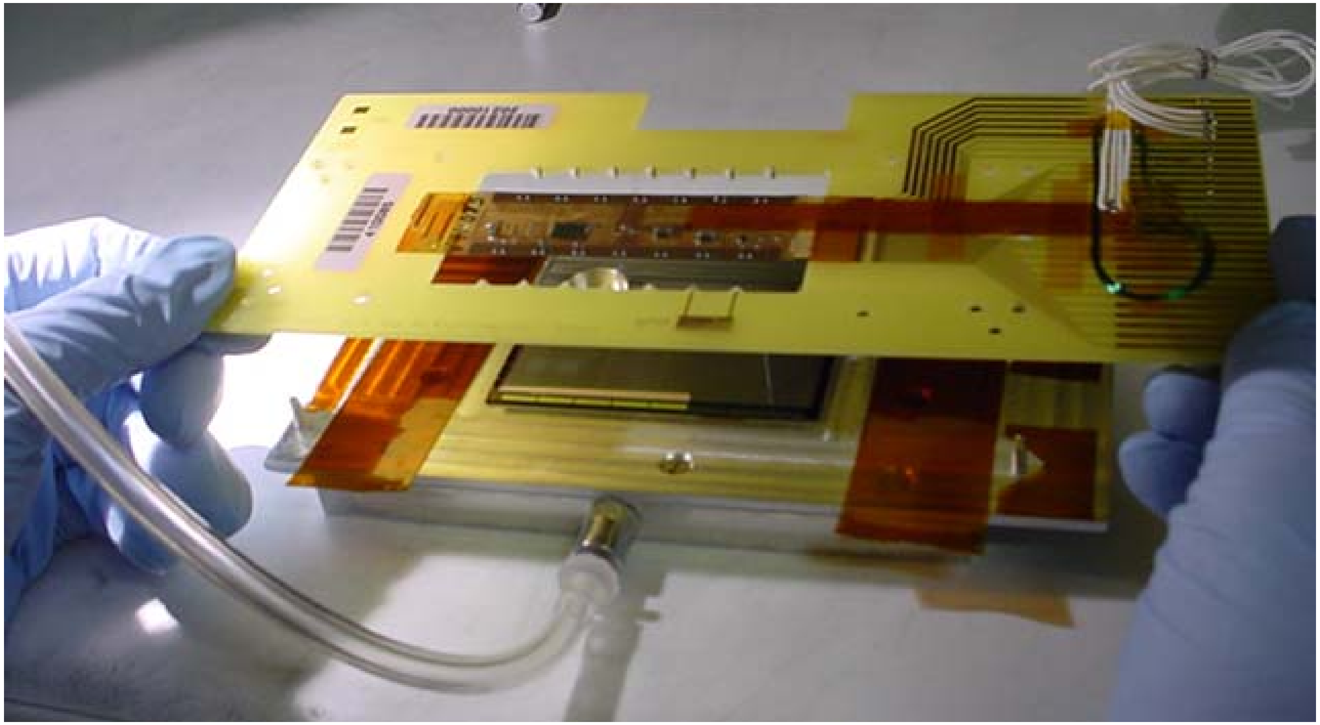
Sensor	Bumps	Conf.	ε [%]
Tesla	IZM	A	98.07
		B	98.41
Tesla	AMS	A	97.91
		B	98.36
CiS	IZM	A	98.62
		B	98.82



M. Gilchriese

Module Assembly/Test

- Flex hybrids are fabricated and loaded, sent to LBNL(and other locations).
- Flip chip bonding of FE IC's to sensors done in Germany and Italy. "Bare modules" sent to LBNL(and other locations).
- Assembly, wire bonding and test of modules done here.



Pixel Plan

- Production sensors are now under fabrication and will be done by end 2003.
- Pixel mechanics partly in production, the rest starts next year.
- Next iteration of ICs by Spring 2003.
- Module production begins in Summer 2003 and continues into 2004.
- Integration of modules with mechanical structure in 2003 into 2004 and then overall testing in 2004 in new clean room (general LBNL facility) recently completed.
- Action moves completely to CERN by early 2005, for surface assembly and test.
- Installation in-pit in early 2006.

M. Gilchriese

Pixel R&D

- The pixel detectors under construction now will be the first pixel systems at hadron colliders. Improvements can be made.
- The principal route to an LHC upgrade is to increase the luminosity beyond 10^{34}.
- This has two important implications for pixel detectors
  - Increased system (larger radius) to replace silicon strip detectors. $1m^2$-> $10m^2$.
  - Increase radiation resistance 25MRad -> 100MRad or more
- Lengthy R&D is required to meet these challenges. We would like our focus to be
  - Improve electronics performance and migrate to 0.13μ. We expect to have access to 0.13μ in 2003.
  - Reduce system complexity and material. This requires new mechanical/cooling structures, powering schemes, possibly data transmission. Starting on this via DoE SBIR.
- In the past much of this type of R&D had been supported by the Division and the Lab Directorate. This will be much harder in the future but this R&D is essential to maintain LBNL's leading role in silicon detector technologies.

Outlook for the Next Year

- Total Divisional funding for ATLAS in FY03 reduced by about 20% compared to FY02. This impacts all aspects of our work
  - Cancellation of postdoc search with candidates in hand and slowed down postdoc hiring to less than a replacement level.
  - Reduction in LBNL software engineering that will lead the U.S. to renege on an agreement with CERN
  - Significant call on ATLAS project contingency to support Divisional staff. It's too soon to tell if this will be granted or if the LBNL technical role in ATLAS will be reduced.
- We have asked the DoE to partially restore the cut and have asked the U.S. ATLAS management to provide funds for both computing personnel(answer is no funds available) and for technical personnel(pending)

Outlook for Beyond the Next Year

- Planning in the U.S. for the project-organized part of the "Research Program" phase of ATLAS is advancing and we have prepared estimates for
  - A continuing role in ATLAS computing/simulation beyond first collisions
  - Technical support of operations and maintenance by LBNL staff
  - Upgrade R&D(pixels)
- The most critical part of future planning, namely physicist staffing levels and particularly postdocs, is not yet understood nationally and the continuous Division budget crisis prevents real local planning.
- It had been our hope to roughly add one postdoc(to the current ~ 3) per year starting in 2003 until about 1st collisions. This will have to be delayed.
- Permanent staff levels are likely to be roughly flat but would hope that junior faculty/Divisional Fellow would join ATLAS in the next two years or so.

Concluding Remarks

- It's been a great year for progress on all aspects of our scientific and technical work on ATLAS!
- The efforts from our strong software and physics simulation team have matured and the first significant data challenge is complete.
- We have started the production phase for the silicon strip detector system.
- Led by LBNL, first demonstration that LHC requirements for pixel electronics and modules can be met. Parts of the pixel system are now also in production.
- Our most significant immediate challenge is no longer technical but the financial health of the Physics Division.